

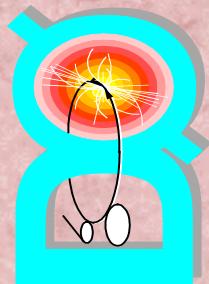


Prospects for top physics with 15fb⁻¹ at DØ

Alice Bean
Fermilab/University of Kansas
5/27/2

OUTLINE

1. Run and detector plans
2. Parameters to be measured
3. Detector requirements
4. Projections for top measurements



Accelerator Plans



The Run2b accelerator plans can be found in 12/01 document:
<http://www-bdnew.fnal.gov/pbar/run2b/Documents/TDR/tdr.pdf>

"The GOAL of Run2b is integrated 15fb^{-1} by 2008"

Run	Typical Luminosity ($\times 10^{31} \text{ cm}^2 \text{ sec}^{-1}$)	Integrated Luminosity (pb^{-1}/wk)
Ib	1.6	3.1
IIa (without Recycler)	8.6	17.1
IIa (with Recycler)	11.9	23.4
IIb	41.0	80.9



DO

Integrated Luminosities

Run I - accumulated 120 pb^{-1}

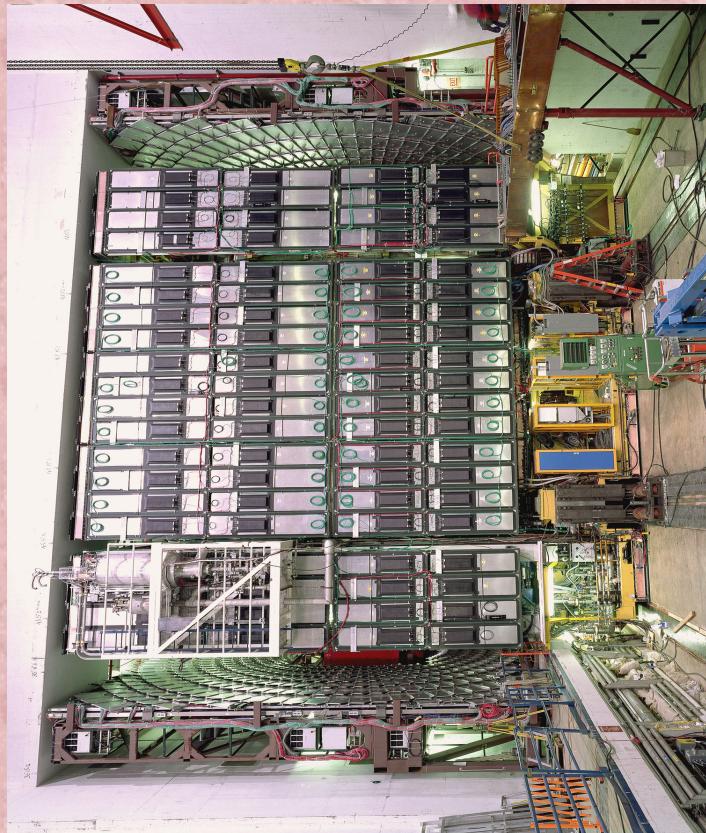
Run 2a - expect $2\text{-}4\text{ fb}^{-1}$

Run2b - expect summed with
Run2a a total of 15 fb^{-1}



Run I detector

Energy increased from 1.8 TeV
in Run I to 1.96 TeV in Run 2



Run 2a detector



DO Run2b

In order to exploit the luminosity delivered, DO plans two sets of upgrades for 2005:

- A new silicon detector as the Run2a silicon detector will become radiation damaged

- Trigger:

L1 track trigger

L1 calorimeter trigger

L1 cal-track matching

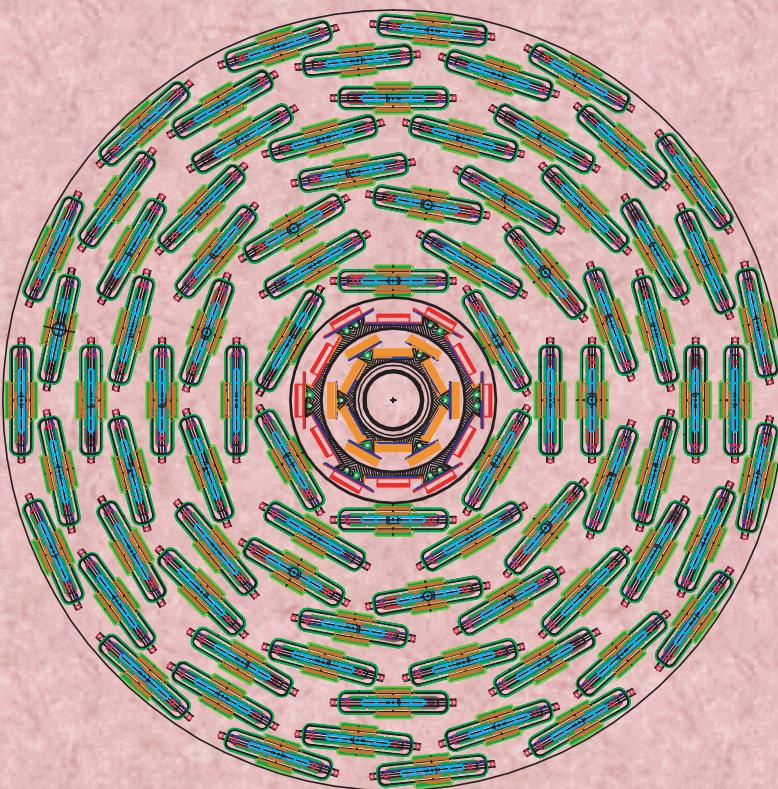
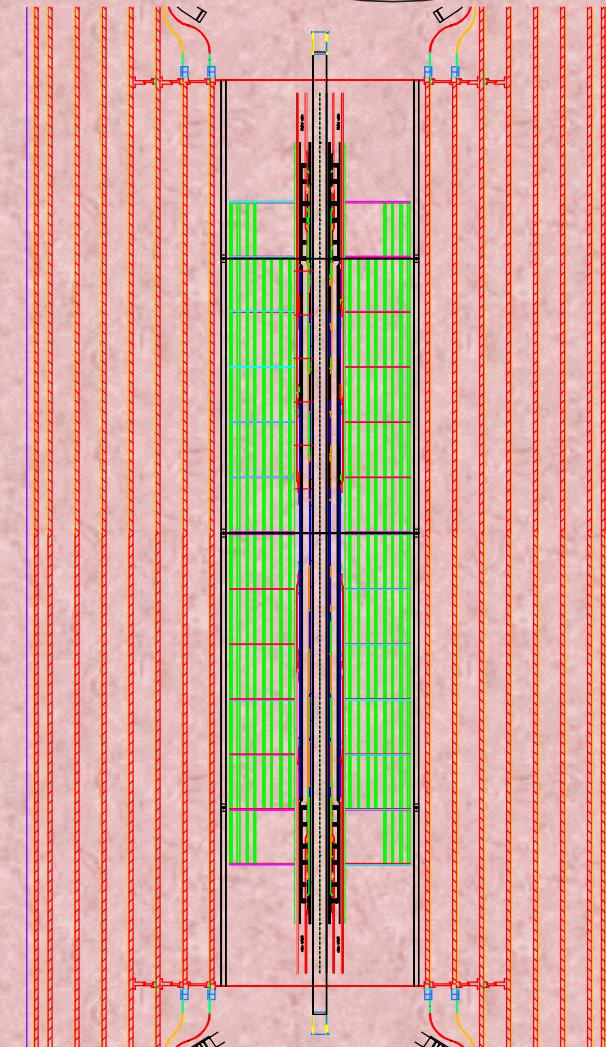
L2 upgrades



Run2b silicon detector



D0 Run2b silicon detector



L0 is at a radius of ~18mm improving impact parameter resolution and thus b-tagging efficiency

Uses single-sided silicon



D0 Track Trigger

To be able to get the jet energy scale needed for top mass measurements

→ we need to trigger for $Z \rightarrow b\bar{b}$ and avoid prescales

Trigger on displaced tracks at L2 using the silicon info!

Silicon Track Trigger (STT) added into Run2 detector after baseline

The STT is on time, due for Run2a: Summer 2002,
will be upgraded for Run2b

Simulations show signal efficiency of 20% with background rate of 20Hz achievable



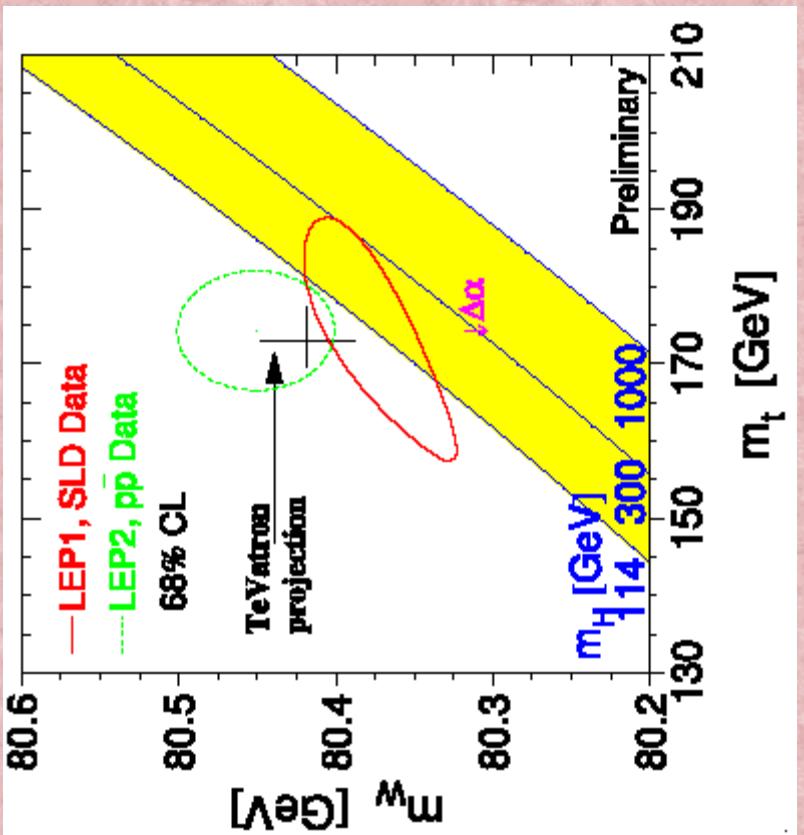
Parameters to be measured

- ◆ Mass and Width of the Top quark - m_t , Γ
- ◆ Cross sections
 - * $t\bar{t}$ cross section - $\sigma_{t\bar{t}}$
 - * dilepton cross section / lepton + jets cross section -
 $\sigma_{||} / \sigma_{l+j}$
 - * single top cross sections
- ◆ Decay branching ratios
 - * $t \rightarrow W b$ from: $N(bb)/N(bX)$, $N(l\bar{l})/N(lX)$, using single top
 $\Rightarrow V_{tb}$
 - * $t \rightarrow W_{V+A}$  Polarization of W
 - * $t \rightarrow W_{long}$
- ◆ Rare Decays
 - * $t \rightarrow c\gamma$
 - * $t \rightarrow cZ$
 - * $t \rightarrow Hb$

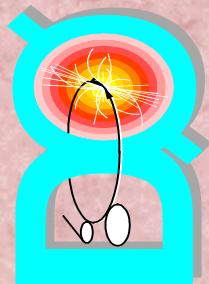


Testing the Standard Model

- ◆ For $m_t = 175 \text{ GeV}$
 - * $\sigma(pp \rightarrow t\bar{t}) \sim 7 \text{ pb}$
 - * $\sigma(pp \rightarrow t\bar{b}) \sim 0.7 \text{ pb}$
 - * $\sigma(pp \rightarrow t\bar{q}b) \sim 1.5 \text{ pb}$
 - * constrain Higgs mass
 - ◆ $(W_{\text{long}}/W_{\text{left}}) = 0.5 (m_t/m_W)^2$
 - ◆ $|V_{tb}| \geq 0.998$
 - ◆ Decays:
 - * $t \rightarrow Wb + g/\gamma$,
 - * $t \rightarrow Wb + Z$,
 - * $t \rightarrow Wb + H^0$,
 - * $t \rightarrow W + s/d$



Using the measurements of top mass and W mass, one can obtain indirect Higgs mass constraint



Beyond the Standard Model



Need to explain electroweak symmetry breaking and dynamics
responsible for mass

What to look at?

* Light Related States

- ◆ top squarks
- ◆ exotic quarks
- ◆ charged scalar bosons
- ◆ Flavor Changing Neutral Current (FCNC) rare decays

* Compositeness

* Unusual Quantum Numbers

- ◆ Extended Strong Int.
- ◆ Extended Hypercharge Int.
- ◆ Extended Weak Int.



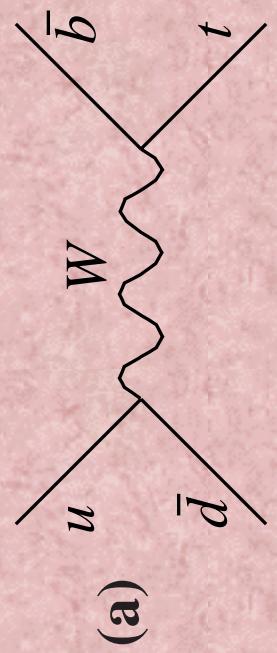
Single Top

Direct access to W - $t\bar{b}$ vertex

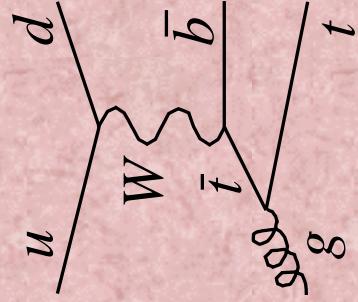
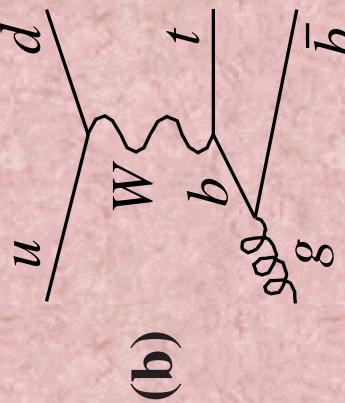
$$\sigma(qq \rightarrow t\bar{b}) \propto \Gamma(t \rightarrow W + b) \propto |V_{tb}|^2$$

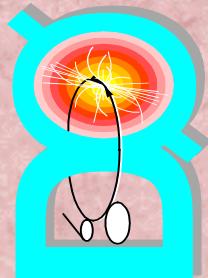
- $|V_{tb}|$ measurement without number of generations assumption
- Measurements of the W and top helicities
- New physics?

s channel - Drell Yan



t channel - W -gluon fusion





Some References

- ① TeV 2000 (1996)
D. Amidei, R. Brock et al. Fermilab-Pub-96/082
- ② Top Quark Physics: Future Measurements (1997)
R. Frey et al.
HEP-PH/9704243
- ③ THINKSHOP (2000)
http://web.hep.uiuc.edu/home/kpaul/thinkshop/thinkshop_alt.htm
- ④ The Snowmass Report on Precision Electroweak Measurements (2001)
U. Baur et al.
HEP-PH/0202001





Event samples

✿ $t\bar{t}$ events

◆ 3 main samples:

- * lepton + 3/4 jets (workhorse for top mass measurement)
- * dilepton (clean sample with low background but smaller statistics)
- * all jets

✿ Single Top decays

◆ lepton, missing transverse energy and:

- * s-channel: 2 high P_T b jets
- * t-channel: high P_T central b jet (from top decay)
soft, central b jet
high P_T forward light quark jet

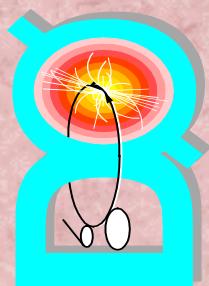




Detector Requirements

- ◆ Trigger on lepton+jets
 - ◆ Good high p_T Lepton identification for $|\eta| < 2$
 - ◆ b-jet tagging
 - * Secondary Vertex b-tagging
 - * soft lepton tagging
- Definitions (Assumes for $|\eta| < 2$)**
- Efficiencies per b-jet of at least 50%
 - Probability for tagging at least one jet per event of greater than 70%
 - Probability for tagging two jets per event of greater than 30%





Lepton Identification



Electrons

$$|\eta| < 2.4$$

Liquid Argon calorimetry upgraded with faster electronics for Run2

Added preshower detectors to help with soft electron reconstruction

Muons

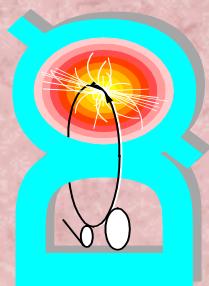
$$|\eta| < 2.0$$

Upgraded system in trigger,
timing and shielding



Both systems are performing well and with the specifications needed for Run2 physics!

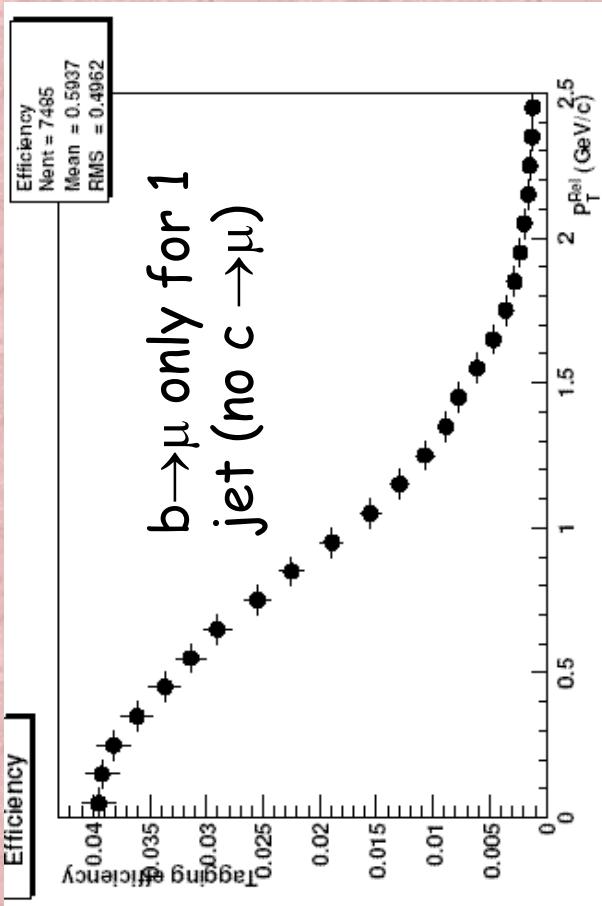
Muon trigger pixels



b-tagging - Soft Lepton

- DO only used lepton tagging for b-jets in Run I
- b-tagging probability is the sum of leptons from both the b and c quark decays and from normally 2 b quark decays per event
- Run I for top analyses b-tagging probability 10-20% depending on analysis for muon tagging

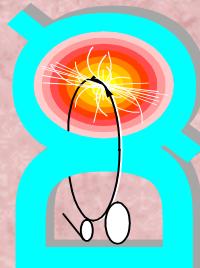
Run 2a and Run2b



Will now use both electrons and muons looking at p_T relative to jet

Both perform as well as Run I in Monte Carlo studies

Muon tagging has been checked in data for bb decay studies



b-tagging Secondary Vertices

None for Run I

Run 2a

we have both impact parameter
and secondary vertex algorithms

MC studies of $t\bar{t}$ events

Secondary vertex tag:

eff ~52%, mistag ~2%

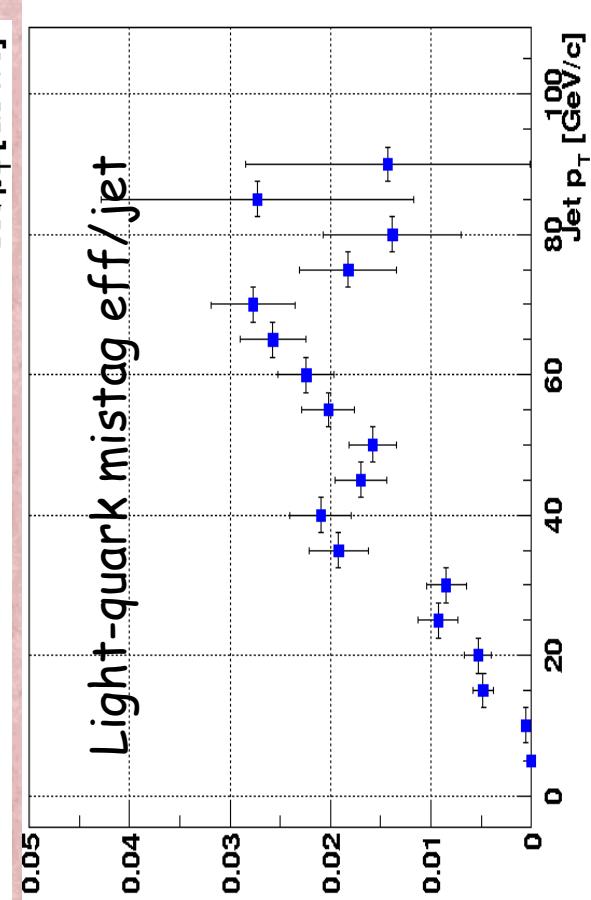
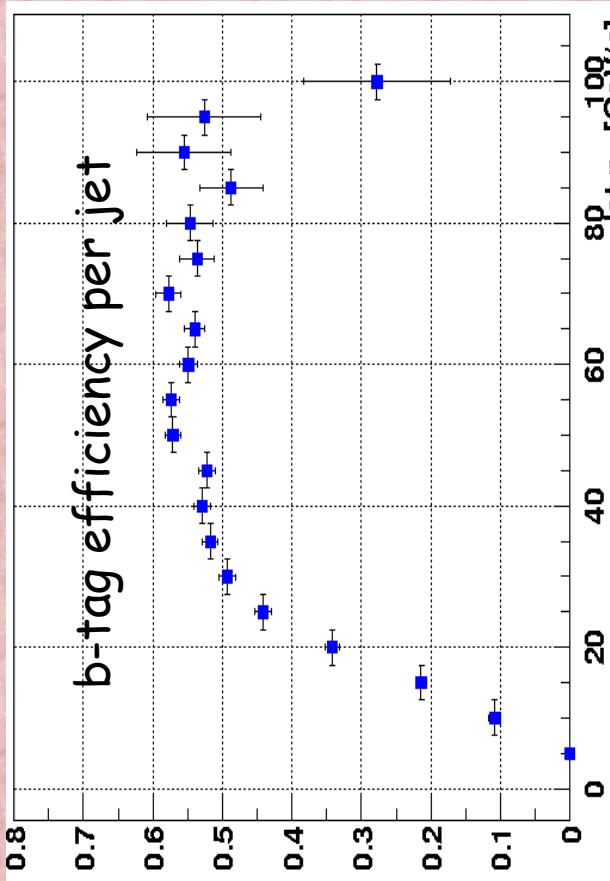
This is a per jet efficiency

For WHiggs events with H
decaying to bb, the per jet
tagging efficiency is 55%

Combined Vertex and Lepton
Probability per event (Preliminary)

for 2 b-tags 31%

for ≥ 1 b-tag 79%





b-tagging efficiency for Run2b using Impact Parameter

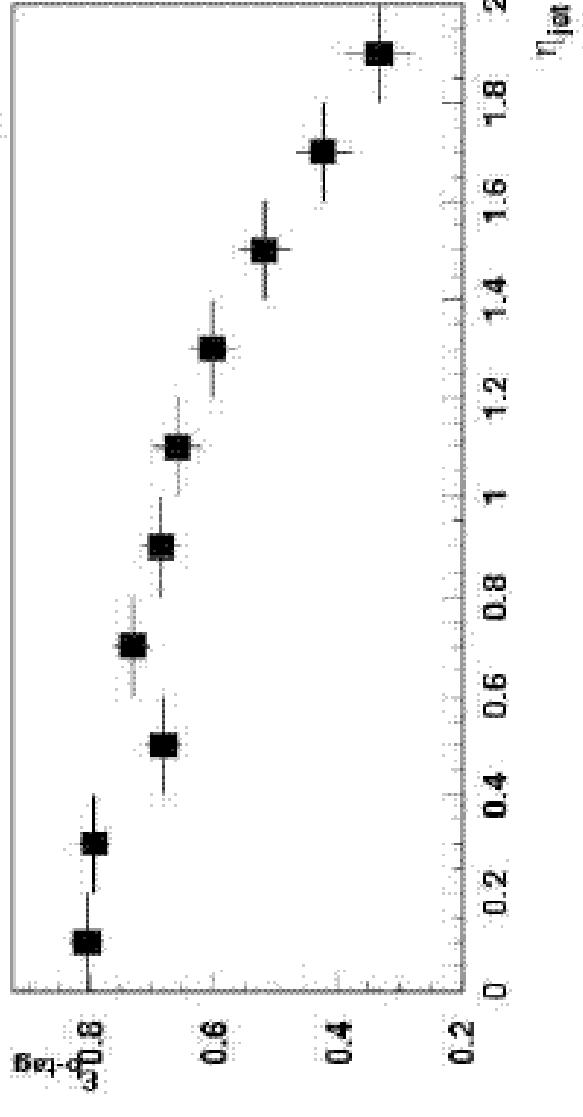
Probability per event

	TDR
$P(n_b \geq 1)$	76%
$P(n_b \geq 2)$	29%
Mistag Rate	< 1.5 %

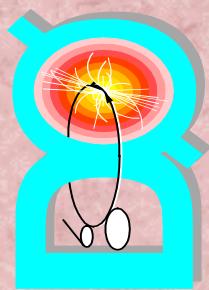
Probability per jet

For WH events, the per jet b-tag efficiency is 69% which is 19% better than in Run2a

Based on WH-events, with b's falling within acceptance



With Sum of Vertex and Semileptonic b-tags, we expect to have a probability per event of well over 80% for 1 tag



Top Mass Measurement



DO RunI measurement:

1+jets: $173.3 \pm 5.6 \pm 5.5$ GeV

Using $t\bar{t}$ sample with 15 fb⁻¹:

3200 lepton+jets events with double
1200 untagged dilepton events

Use $Z \rightarrow b\bar{b}$ decays to limit Jet
Energy Scale error

Gluon Radiation Corrections
in the MC generator will be
studied by comparing
double-tagged events with
simulations

1+jets sample only

Largest Systematics	Error in GeV
Jet Energy Scale	4.0
MC Generator	3.1
Noise/Pile-up	1.3

Run 2 errors with 15 fb ⁻¹	Error (GeV)
Statistical	0.6
Jet Energy Scale	0.5
MC Generator	1.0
Noise/Pile-up	0.2
Total	1.3



Single Top Measurements

Effort underway to increase signal-to-background (S/N)

Run I, without using secondary vertex b-tagging: $S/N \approx 1:25$
expect S/N to improve to 1:2-3

with **15 fb⁻¹**:

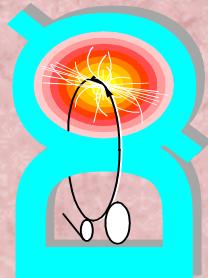
yields expected	s-channel	150
all		1200

Will use the s-channel to measure $|V_{tb}|$ with the best errors
This measurement doesn't have to assume 3 generations

Estimated errors:

Cross section σ_{tbX} measured to 10%
 $\Gamma(t \rightarrow W+b)$ measured to 12%
 $|V_{tb}|$ measured to 8%





Rare Decays

$t \rightarrow q\gamma, t \rightarrow qZ, t \rightarrow Hb, \text{others?}$

The Standard Model predicts FCNC at level of 10^{-10} in branching fraction

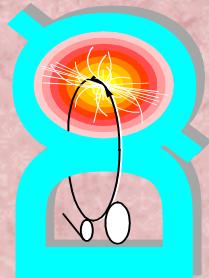
In Run I, CDF obtained 95% C.L. limits of

$$B(t \rightarrow q\gamma) < 3.2\% \quad B(t \rightarrow qZ) < 33\%$$

Predicted limits for D0 with 15 fb^{-1} :

	$\delta\sigma \cdot B(Z' \rightarrow tt)$	$B(t \rightarrow c\gamma)$	$B(t \rightarrow cZ)$	$B(t \rightarrow Hb)$
Ref. ①	$< 4.0 \times 10^{-4}$	$< 3.8 \times 10^{-3}$	$< 6\%$	





Predicted Errors for D0 from each dataset

	Run I (120 pb ⁻¹) D0 meas.	Run I CDF meas. D0 meas.	Run 2a (2 fb ⁻¹) Error	Run 2b (15 fb ⁻¹) Error	≥1
m_t (GeV/c ²)	172.1 ± 7.1	176.0 ± 6.5	2		
$\sigma_{t\bar{t}}$ (pb)	5.9 ± 1.7	$6.5^{+1.7}_{-1.4}$	8%	5-6%	
$\sigma(tX)$ (pb)	<17	<18	20%	<10%	
$\sigma(tqX)$ (pb)	<22	<13	20%	10%	
F_0 (W hel.)	0.9 ± 0.4	0.9	8%	3%	
σ_{ll}/σ_{l+j}			10%	4-5%	
$ V_{tb} $ w/o 3 gen.	>0.046	15-20%	8%		





Conclusions

- ◆ DO plans to take data accumulating 15fb^{-1} by 2008
 - * to do this, we will upgrade our trigger and install a new silicon detector
- ◆ There are many studies of what the errors on top parameters will be
- ◆ The assumed b-tagging efficiencies for previous studies are probably in the range of our capabilities
- ◆ Top Physics may be where the majority of understanding of electroweak symmetry breaking will occur
- ◆ We anticipate an exciting 5 years ahead of us!

